APPLICATION FOR

UNITED STATES LETTERS PATENT

SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

Be it known that **Ronald Kronenberger** residing in Riverwoods, Illinois , has invented a new and useful **"METHOD OF SELECTING DRAW TENSION FOR THREAD ON A STITCHING SYSTEM AND A KIT FOR FACILITATING THE SELECTION"** of which the following is a specification.

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METHOD OF SELECTING DRAW TENSION FOR THREAD ON A STITCHING SYSTEM AND A KIT FOR FACILITATING THE SELECTION

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

This invention relates to stitching systems utilizing a bobbin case assembly from which a stored supply of thread is drawn and, more particularly, to a bobbin case assembly having an associated thread tensioning element against which the thread paying off of the supply acts to produce controlled resistance to the payout of thread from the supply.

BACKGROUND OF THE INVENTION

In sewing/stitching operations, and particularly in embroidery operations, the tension of two source components forming the lockstitch needle thread and bobbin thread must balance to achieve a high quality stitch. If the tension in the needle thread is significantly greater than the bobbin thread tension, the bobbin thread can be pulled from through the underside of the fabric and show at the top side of the fabric being sewn. This condition can cause puckering of the fabric or disfigured sewing to occur. If the needle thread tension is significantly less than the bobbin thread tension, loops can form on either side of the fabric and the stitching formation can appear loose or distortedly large.

A primary job of a sewing equipment operator is to keep bobbin and needle thread tensions as close as possible to balanced. The method of balancing thread tension has historically been carried out by having the sewing operator observe the pattern after stitches are laid down. Good sewing operators constantly adjust the tension of both needle and bobbin threads to maintain the proper balance. Less skilled operators may not consistently maintain this balance as a result of which poor quality stitch formation may result.

The assignee herein is the owner of U.S. Patent No. 6,152,057, which is directed to a bobbin case assembly with an associated tensioning element having a circumferential surface about which thread is wrapped to controllably increase thread draw tension. During setup, the sewing equipment operator can control the degree of wrapping of the thread around the tensioning element to thereby select the desired thread draw tension associated with that bobbin case assembly. This potentially obviates complex and time consuming adjustment procedures used in conventional sewing systems, which may incorporate a large number of sewing "heads". While the system disclosed in U.S. Patent No. 6,152,057 represents a tremendous contribution to the industry, there are some inherent limitations associated therewith.

First of all, in the event that a significant increase in draw tension is required, multiple wraps of the thread around the tensioning element may be

required. This results in a spiral arrangement of the thread around the tensioning element. The spiral pattern of the wrapped thread may shift during operation relative to the tensioning element, which may result in an appreciable draw tension variation.

Another drawback with this design is that it may not lend itself to universal application in industries that use "post-wound" and "pre-wound" bobbins. Pre-wound bobbins are generally supplied in operations that have low or moderate volume capability. The thread sources for these operations pre-wind thread on bobbins. The thread type and its tack are controlled by the thread supplier. The thread tack is an important feature to consider, using the system in U.S. Patent No. 6,152,057, in that a change in the tack characteristics of the thread may appreciably change the coefficient of friction between the thread and the cooperating surface of the tensioning element. This, in turn, results in a change in operating thread draw tension.

In high volume stitching operations, it is economically desirable, and practical, to wind bobbins with thread on-site. By doing so, the cooperating frictional characteristics, between the thread and tensioning element, which are attributable in part to the tack on the thread, may be different by reason of the fact that different winding and treating procedures are practiced on-site compared to those used in facilities that pre-wind the bobbins. Consequently, thread with a

particular specification may account for draw tensions that are different for a given bobbin case assembly configuration, depending upon whether the thread is pre-wound or post-wound.

Accordingly, for a given configuration of a bobbin case assembly with a specific tensioning element, it may be difficult to control draw tension to the desired magnitude by simply controlling the wrap characteristics. As a result, the system operator may select the wrap pattern to be within an acceptable range, close to but not at, the optimal draw tension magnitude. This may translate into some loss of quality in the performed stitching.

The industry continues to seek out ways to predictably select draw tensions, at or close to a desired value, using both post- and pre-wound bobbins, without complicated setup procedures or excessive adjustment as the system is monitored both at start-up and during use.

SUMMARY OF THE INVENTION

In one form, the invention is directed to the combination of a first bobbin case assembly and a second bobbin case assembly. The first bobbin case assembly has a first wall structure, mountable operably upon a support and defining a first receptacle within which a first supply of a first thread is stored, and a first tensioning element having a circumference defined by a first surface. The

first thread projects from the first receptacle and is wrapped at least partially around the circumference of the first tensioning element. A first frictional force of a first magnitude, resisting drawing of the first thread from the first receptacle, is generated between the first surface and the first thread so that a first draw tension is required to be applied to the first thread to draw the first thread from the first receptacle with the first bobbin assembly operably mounted on the support. The second bobbin case assembly has a second wall structure, operably mountable upon a support and defining a second receptacle within which a second supply of a second thread is stored, and a second tensioning element having a circumference defined by a second surface. The second thread projects from the second receptacle and is wrapped at least partially around the circumference of the second tensioning element so that a second frictional force of a second magnitude, resisting drawing of the second thread from the second receptacle, is generated between the second surface and the second thread so that a second draw tension is required to be applied to the second thread to draw the second thread from the second receptacle with the second bobbin case assembly operably mounted on a support. The magnitudes of the first and second frictional forces are different. The first and second bobbin case assemblies can be selectively operably mounted upon a support to select one of the first and second draw tensions.

The combination may further include a support upon which the first and second bobbin case assemblies can be selectively operably mounted.

The combination may further include a thread drawing mechanism that is part of a thread stitching system. The thread drawing mechanism is engageable a) with the first thread with the first bobbin case assembly operably mounted on the support and b) with the second thread with the second bobbin case assembly operably mounted on the support to draw the first and second threads from the first and second receptacles as the thread stitching system is operated.

In one form, there is a first coefficient of friction between the first thread and the first surface and a second coefficient of friction between the second thread and the second surface and the first coefficient of friction is different than the second coefficient of friction.

In one form, the first and second surfaces have different characteristics that account for the difference in the first and second coefficients of friction.

In one form, the first and second surfaces have different areas that are contacted respectively by the first and second threads and that account for the difference in the magnitudes of the first and second frictional forces.

In one form, the first and second surfaces have different frictional characteristics that account for the difference in the first and second coefficients of friction.

In one form, the first and second surfaces have different compositions that account for the difference in the first and second coefficients of friction.

In another form, the first and second surfaces have different textures that account for the difference in the first and second coefficients of friction.

The first and second threads may have different characteristics that account for the difference in the first and second coefficients of friction.

In one form, the first wall structure bounds the first receptacle and the first bobbin case has a first bobbin in the first receptacle around which the first supply of thread is wrapped. The first bobbin is supported for rotation around a first axis relative to the first wall structure as the first thread is drawn out of the first receptacle.

In one form, the first wall structure has a first peripheral wall extending around the first axis and having a first opening through which the first thread projects to engage the first tensioning element.

In one form, the first tensioning element is cantilevered from the first peripheral wall.

The invention is further directed to the combination of a bobbin case assembly, a first tensioning element having a circumference defined by a first surface, and a second tensioning element having a circumference defined by a second surface. The bobbin case assembly has a wall structure mountable in an

operative position upon a support and defining a receptacle within which a supply of thread is stored. The first and second tensioning elements are interchangeably mountable in an operative position to the wall structure. With the first tensioning element mounted in an operative position on the wall structure, the thread from the supply can be directed against the first surface so that a first frictional force of a first magnitude, resisting drawing of the thread from the receptacle, is generated between the first surface and the thread so that a first draw tension is required to be applied to draw the thread from the receptacle. With the second tensioning element mounted in an operative position on the wall structure, the thread from the supply can be directed against the second surface so that a second frictional force of a second magnitude, resisting drawing of the thread from the receptacle, is generated between the second surface and the thread so that a second draw tension is required to be applied to draw the thread from the receptacle. The first and second magnitudes are different. The first and second tensioning elements can be selectively mounted in an operative position on the wall structure to select one of the first and second draw tensions.

The combination may further include a support to which the wall structure is operably mounted and a thread drawing mechanism that is part of a thread stitching system. The thread drawing mechanism is engageable with the thread to draw the thread from the receptacle as the thread stitching system is operated.

In one form, there is a first coefficient of friction between the thread and the first surface and a second coefficient of friction between the thread and the second surface. The first coefficient of friction is different than the second coefficient of friction.

In one form, the first and second surfaces have different characteristics that account for the difference in the first and second coefficients of friction.

The first and second surfaces may have different areas that are contacted respectively by the first and second threads that account for the difference in the magnitudes of the first and second frictional forces.

In one form, the first and second surfaces have different frictional characteristics that account for the difference in the first and second coefficients of friction.

The first and second surfaces may have different compositions that account for the difference in the first and second coefficients of friction.

The first and second surfaces may have different textures that account for the difference in the first and second coefficients of friction.

The invention is further directed to a method of selecting draw tension for thread that is engaged by a thread drawing mechanism in a stitching system and drawn from a supply of thread on a bobbin case assembly that is operably mounted on a support. The method includes the steps of: providing a first bobbin

case assembly configuration that causes a first predetermined thread draw tension to result with the first bobbin case assembly configuration operably mounted on the support, attributable at least in part to a first frictional resistance force generated between thread on the first bobbin case assembly and a first circumferential surface on a first tensioning element on the first bobbin case assembly configuration; providing a second bobbin case assembly configuration that causes a second predetermined draw tension, different from the first predetermined draw tension, to result with the second bobbin case assembly configuration operably mounted on the support, attributable at least in part to a second frictional resistance force generated between thread on the second bobbin case assembly and a second circumferential surface on a second tensioning element on the second bobbin case assembly configuration being different than the first frictional resistance force; and selectively operably mounting one of the first and second bobbin case assembly configurations to the support based on a thread draw tension that is desired.

In one form, the step of providing first and second bobbin case assembly configurations involves using threads having at least one of a) a different composition, b) a different structure, and c) a different size on the first and second bobbin case assembly configurations to cause the first and second frictional resistance forces to be different.

The steps of providing first and second bobbin case assembly configurations may involve providing the first surface with a first frictional characteristic and the second surface with a second frictional characteristic that is different than the first frictional characteristic to cause the first and second frictional resistance forces to be different with the first and second bobbin case assembly configurations used in conjunction with the same thread.

The steps of providing the first surface with a first frictional characteristic and the second surface with a second frictional characteristic may involve providing the first and second surfaces with a different area that is engaged by thread on the first and second bobbin case assembly configurations.

The step of providing the first surface with a first frictional characteristic and the second surface with a second frictional characteristic may involve providing different compositions for the first and second surfaces.

The steps of providing the first surface with a first frictional characteristic and the second surface with a second frictional characteristic may involve providing different textures for the first and second surfaces.

The step of providing first and second bobbin case assembly configurations may involve providing complete, fully operable, separate, first and second bobbin case assembly configurations that can be interchangeably operably mounted on the support.

In one form, the step of providing the second bobbin case assembly configuration may involve reconfiguring the first bobbin case assembly configuration.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic representation of a stitching system which generically identifies an environment within which the present invention can be practiced;

Fig. 2 is a schematic representation of one form of bobbin case assembly, on the stitching system of Fig. 1, and mounted upon a support and from which thread is withdrawn by a thread drawing mechanism;

Fig. 3 is a further schematic representation of the bobbin case assembly in Figs. 1 and 2, mounted on a support;

Fig. 4 is a partially schematic, perspective view of the bobbin case assembly in Figs. 1-3 and incorporating a thread tensioning element upon which thread is wrapped, and against which the thread acts, as it is drawn from the bobbin case assembly;

Fig. 5 is a schematic representation of a kit, according to the present invention, including first and second self-contained bobbin case assemblies with tensioning elements that cooperate with supplies of thread to account for different thread draw tensions;

Fig. 6 is a cross-sectional view of the threads on the first and second bobbin case assemblies in Fig. 5, which have a different diameter so as to account for different thread draw tensions;

Fig. 7 is a view as in Fig. 6 wherein the threads have a different composition to account for different thread draw tensions;

Fig. 8 is a fragmentary, elevation view of a length of the threads on each of the bobbin case assemblies in Fig. 5, and showing different thread constructions which account for different thread draw tensions;

Fig. 9 is a cross-sectional view of one form of the tensioning elements, on the first and second bobbin case assemblies in Fig. 5, wherein the circumferential surfaces thereof have a different roughness to account for different thread draw tensions;

Fig. 10 is a view as in Fig. 9 wherein one of the tensioning elements is uncoated and the other has a coating to account for different thread draw tensions;

Fig. 11 is a fragmentary, elevation view of the tensioning elements on the first and second bobbin case assemblies in Fig. 5, wherein one of the tensioning elements has a layer wrapped therearound and the other tensioning element is without a wrapped layer to account for different thread draw tensions; and

Fig. 12 is a schematic representation of another form of kit, according to the present invention, which includes tensioning elements which can be

interchangeably mounted upon a wall structure to select predetermined thread draw tensions.

DETAILED DESCRIPTION OF THE DRAWINGS

In Fig. 1, a schematic representation of a sewing system/stitching system 10 (hereinafter referred to as "a stitching system") is shown to represent a generic environment for the present invention. The stitching system 10 can have any number of components which perform single thread stitching, lock-stitching, chain-stitching, and virtually any other type of stitching known to those skilled in this art. The pertinent components of the stitching system 10, for purposes of this invention, are a bobbin case assembly 12 having a thread supply 14 therein, and a thread drawing mechanism 16. The thread drawing mechanism 16 shown is intended to identify virtually any mechanism used in sewing/stitching operations which generates a draw tension on an operative thread to draw the same from the supply 14.

Additional detail, setting out the environment for the present invention, is shown for the stitching system 10 in Fig. 2. The bobbin case assembly 12 consists of a wall structure 18 which defines a receptacle within which a bobbin 20 is received. The bobbin 20 has the thread supply 14 wrapped therearound. The bobbin 20 is movable relative to the wall structure 18 to allow the thread from the

supply 14 to be paid out as it is pulled by the thread drawing mechanism 16. The wall structure 18 is operably mounted upon a support 22 of the type typically associated with sewing/stitching systems.

As shown in Fig. 3, the wall structure 18, in one exemplary form, consists of a bobbin basket assembly 24, which supports the bobbin 20 and mates with a bobbin case 26 in a manner that the bobbin 20, with the thread supply 14 thereon, is captive between the bobbin case 26 and bobbin basket assembly 24. The bobbin case 26 is separable from the bobbin basket assembly 24 to facilitate installation and removal of the bobbin 20. The bobbin basket assembly 24 is directly or indirectly mounted to the support 22.

In Fig. 4, a more detailed depiction of the bobbin case assembly, into which the present invention is incorporated, is shown at 12. As previously described, the bobbin case assembly 12 consists of the bobbin basket assembly 24, which has a bottom wall 28 and an annular, peripheral wall 30 extending upwardly therefrom, and defining in conjunction therewith, a receptacle 32 for the bobbin 20. A mounting post 34 projects upwardly from the bottom wall 28 and extends through a hollow core 36 on the bobbin 20. The bobbin 20 is thereby supported for rotation around an axis 38.

The thread 14 is wrapped around the core 36 and is directed radially outwardly through an opening 40 in the peripheral wall 30. The bobbin 20 has

axially spaced flanges 42, 44 at the ends of the core 36, which bound a thread storage space on the bobbin 20. The mounting post 34 is engaged by the bobbin case 26, which is separably attached thereto so that the bobbin case 26 and bobbin basket assembly 24 captively maintain the bobbin 20 in its operative position. The bobbin basket assembly 24 is suitably attached to the support 22.

The portion of the thread 14 departing from the opening 40 is engaged by the thread drawing mechanism 16. As the thread drawing mechanism 16 exerts a tension upon the thread 14, the bobbin 20 is caused to rotate about the axis 38, which causes the thread 14 to pay off of the bobbin core 36. As disclosed in U.S. Patent No. 6,152,057, the bobbin case assembly 12 includes a tensioning element 46 which is in the form of an elongate hook consisting of a substantially straight body 48 which terminates at a U-shaped end 50. The tensioning element 46 is cantilever mounted on the peripheral wall. A mounting end 52 of the tensioning element 46 is captively held against the outside surface 54 of the peripheral wall 30 through a mounting plate 56. The mounting plate 56 is fixed in place on the peripheral wall 30 by spaced fasteners 58.

The body 48 of the tensioning element 46 is shown as circular in cross section so as to have a cylindrically-shaped, exposed surface 60 around the circumference thereof. The thread departing from the opening 40 is applied against the surface 60 so that a frictional force is generated between the surface

60 and the thread 14 that resists payout of the thread 14. The frictional resistance force between the thread 14 and surface 60 of the tensioning element 46 can be controlled by determining the degree of contact therebetween. By spirally wrapping additional turns of the thread 14 around the body surface 60, the frictional force between the thread 14 and surface 60 can be increased to thereby increase the draw tension i.e. that force that must be applied through the thread drawing mechanism 14 to draw thread off of the bobbin 20.

The above description is sufficient to understand the operation of the present invention as shown herein incorporated into one exemplary bobbin case assembly construction. Further details of this structure are shown and described in U.S. Patent No. 6,152,057, which is incorporated herein by reference. Additionally incorporated herein by reference is the disclosure in each of U.S. Patent Nos. 6,076,477; 5,617,803; 5, 474,004; and 4,493,278, which describe other details of components suitable for use in the stitching system 10 and operable consistently with the inventive concepts. To understand the present invention, it is necessary only to understand that the thread 14 pays off of the bobbin 20 and bears against the exposed surface 60 of the tensioning element 46 to produce a resisting force that, by being varied, changes the thread draw tension as the stitching system 10 is operated.

According to the invention, the characteristics of the thread 14 and/or the exposed surface 60 on the tensioning element 46 are selectively controlled and coordinated to set the system 10 up to operate with selected, different thread draw tensions. In one form, different forms of bobbin case assembly can be provided to be selectively installed to set predetermined draw tensions. For example, as shown in Fig. 5, two fully operable, separate, first and second bobbin case assemblies 12, 12' are provided which can be interchangeably operably mounted upon the support 22. The first bobbin case assembly 12 has a supply of a first thread 14 which can be engaged with a first tensioning element 46. The second bobbin case assembly 12' has a similar construction, with a supply of a second thread 14' which cooperates with a second tensioning element 46'. The bobbin case assemblies 12, 12' can be sold as a kit for selective installation. With the first bobbin case assembly 12 operably connected to the support 22, a draw tension of a first magnitude is set, while the installation of the second bobbin case assembly 12' will result in the setting of a second draw tension for the thread 14'. The exact draw tension resulting from the use of each of the first and second bobbin case assemblies 12, 12' can either be precisely, or approximately, predetermined. The operator for the stitching system 10 can be appropriately advised of the draw tension characteristics associated with each of the bobbin case assemblies 12, 12'. By making the appropriate selection of bobbin case, it

is possible that few, or no, adjustments of the thread draw tension may be necessary.

The different draw tensions can be established by changing either the coefficient of friction between the thread 14 and the surface 54 on the tensioning element 46 and the thread 14' and the corresponding surface 54' on the tensioning element 46' and/or the areas of contact between the thread 14, 14' and the surfaces 54, 54'. This can be accomplished in a number of different ways in addition to by changing the degree of wrapping of the threads 14, 14' around their respective tensioning elements 46, 46'.

As shown in Fig. 6, the threads 14, 14' are made with a different diameter, with the latter being larger, so that there is a different magnitude of frictional resistance force between the thread 14 and tensioning element 46 and the thread 14' correspondingly wrapped around its associated tensioning element 46'.

Alternatively, as shown in Fig. 7, the threads 14, 14' may have the same diameter but may have a different composition. For example, the thread 14 may be made from one of cotton, polyester, or rayon, etc., with the thread 14' made from a different one of these three fibers, or another fiber. This results in a difference in the coefficients of friction between the threads 14, 14' and their corresponding tensioning elements 46, 46'.

As shown in Fig. 8, the difference in coefficient of friction between the tensioning element 46 and thread 14 and tensioning element 46' and thread 14' may be the result of a difference in structure for the thread. In Fig. 8, the thread 14 is shown to have substantially lengthwise, aligned fibers 62, with the fibers 64 on the thread 14' being braided or otherwise wrapped and bundled so that different coefficients of friction and frictional resistance forces are established between the tensioning element 46 and thread 14 and tensioning element 46' and thread 14'.

As shown in Fig. 9, a different coefficient of friction can be generated by reason of changing the texture of the surfaces 54, 54' on the first and second tensioning elements 46, 46'. For example, the circumferential surface 54 on the tensioning element 46 is roughened, either by applying a coarse coating or by treating the surface 54, as by an abrasion process . On the other hand, the surface 54' can be smoother so that there is less resistance to sliding of the thread 14' against the surface 54' than the thread 14 against the surface 54.

In Fig. 10, the different coefficients of friction between the threads 14, 14' and surfaces 54, 54' are attributable to the use of a coating 68 on a core 69 on the tensioning element 46' that defines an exposed circumferential surface 70. The core 69 of the tensioning element 46' is made from a first material. The material of the coating 68 has different frictional characteristics than material defining the core of the tensioning element 46'. The tensioning element 46, including the

surface 54, may be made entirely from the first material defining the core 69 on the tensioning element 46'.

In Fig. 11, the tensioning element 46 is shown as in Fig. 10. The corresponding tensioning element 46' has a layer 74 which is wrapped around a core 76 to change the frictional characteristics of the surface 54' on the tensioning element 46' compared to the surface 54 on the tensioning element 46.

The above are just examples of ways whereby the frictional characteristics between the thread 14 and tensioning element 46 and thread 14' and tensioning element 46' can be changed. There are virtually a limitless number of different ways that a similar result could be achieved. For example, the tensioning elements 46, 46' can be made entirely of different materials. Alternatively, one might be dipped in a solution that changes the frictional characteristics of its associated surface 54, 54'. Suitable coatings to accomplish the stated ends herein are readily selectable by one skilled in the art. It is only necessary that a) the coating is durable enough to withstand the continuous sliding of thread 14, 14' thereagainst as the stitching system 10 is operated and b) different frictional coefficients and frictional resistance forces be generated between the thread 14 and tensioning element 46' and thread 14' and tensioning element 46'.

The invention contemplates another form of kit, as shown at 80 in Fig. 12, that can be sold to allow a system operator to selectively set thread draw tension

for the system 10. In Fig. 12, the kit 80 consists of a wall structure 18, as previously described, to which a first tensioning element 46 and second tensioning element 46 can be selectively operatively mounted through a suitable mounting structure 82. The precise nature of the mounting structure 82 depends upon the configuration of the first and second tensioning elements 46, 46' to be selectively, operatively mounted.

The surfaces 54, 54' on the tensioning elements 46, 46' account for different coefficients of friction between the surfaces 54, 54' and the thread 14, 14' for the same thread composition, structure, and size. The first and second tensioning elements 46, 46' can be sold as a kit to be interchangeably mounted through the wall structure 18 to selectively set different, predetermined operating draw tensions.

Accordingly, using the inventive concept, first and second different bobbin case assembly configurations can be provided which can be selected by the sewing system operator. The different configurations may cause different predetermined thread draw tensions to result that are attributable at least in part to different frictional resistance forces between the thread 14, 14' and the surfaces 54, 54' on the tensioning elements 46, 46'. The different frictional resistance forces may be attributable to use of threads 14, 14' having different compositions, structures, sizes, etc. and/or the surfaces 54, 54' having different frictional

characteristics which result in there being different coefficients of friction between the threads 14, 14' and surfaces 54, 54'. The different coefficient of friction may result from any of the differences between the surfaces 54, 54', described above, and others that would be understood by those skilled in the art. Also, the area of contact between the thread 14, 14' and surfaces 54, 54' dictates frictional resistance forces.

These different frictional characteristics can be achieved by interchangeably mounting entirely self-contained subassemblies, such as the first and second bobbin case assemblies 12, 12', or by modifying subassemblies, such as by interchangeably mounting different tensioning elements 46, 46' with respect to a wall structure 18 within which a thread supply 14, 14' is provided.

Other variations of the invention are contemplated. For example, different frictional forces affecting draw tension can be selected by making the effective diameter of the surfaces 54, 54' different. Alternatively, the shapes of the surfaces 54, 54' can be different than the cylindrical configuration shown. On or both of the surfaces 54, 54' can be changed from the cylindrical shape so that either one of the surfaces 54, 54' is cylindrical and the other is not, or neither of the surfaces 54, 54' is cylindrical.

The foregoing disclosure of specific embodiments is intended to be illustrative of the broad concepts comprehended by the invention.